Oral Presentations Abstracts

Tuesday, 18th September

Chair: Richard Nelson (President elect SBNS)

Sidlaw • 17.00-18.00

O-1
ARUBA: A Randomized Trial of Unruptured Brain Arteriovenous Malformations

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Purpose: ARUBA seeks to provide outcome data from a controlled clinical trial comparing immediate interventional treatment against that deferred until hemorrhage, to test the benefit of preventive therapy for unruptured BAVMs.

Primary AIM: To determine whether the outcome for medical management alone is superior, or not inferior, to immediate invasive therapy in averting death (any cause) or stroke (symptomatic hemorrhage or infarction).

Secondary AIM: to determine whether treatment of unruptured BAVMs by medical management alone offers a lower risk of death or clinical impairment (Rankin Score ≥2) when compared with the late outcome status after invasive therapy tested at ≥5 years from randomization.

Methods: A prospective randomized clinical trial.

Sample Size: 400 patients (1:1 random assignment).

Patients aged ≥18 years, diagnosed with an unruptured BAVM by MR or angiogram imaging and considered by the local investigators suitable for attempted eradication.

Outcome Measures: The primary outcome is the composite event of death or symptomatic stroke (hemorrhage or infarction confirmed by imaging). Clinical outcome is measured by the Rankin Scale, NIHSS, SF-36, and EuroQol.

Interventions: Patients are randomly assigned to medical management or the addition of endovascular, surgical, and/or radiation therapy for lesion eradication.

Follow-Up planned for 5-10 years from randomization.

Participating Centers: Interested multidisciplinary treatment teams are welcome to join.

Results/Trial Status: Over 190 patients have been enrolled worldwide as of April 2012.

Conclusion: ARUBA continues to recruit patients. The NINDS-appointed Data & Safety Monitoring Board endorses study continuation.

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O-2
Comparative Effectiveness of Treatments for Cerebral Arteriovenous Malformations: Trends in U.S. Nationwide Outcomes from 2000 – 2009

Jason Davies[1], Vijay Yanamadala[2], Ana Rodriguez Hernandez[1], Michael Lawton[1]
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Introduction: The development of multimodality approaches for the treatment of cerebral arteriovenous malformations (AVMs), including microsurgery, endovascular therapy, and radiosurgery, has shifted modern treatment paradigms in the last 10 years. This study examines these changes in detail from a nationwide perspective.

Methods: We examined data from 2001-2009 in the U.S. Nationwide Inpatient Sample, assessing safety, quality, and cost-effectiveness.

We also examined patient demographics (including age, sex, income level, and insurance), presentation hemorrhage status, as well as trends in open surgical and endovascular treatment.

Results: 33,997 inpatient admissions for patients with a primary diagnosis of intracranial arteriovenous malformation were identified. The mean hospital charges increased two-fold without significant differences in outcomes. There were substantial differences between surgery, endovascular, radiosurgery, and multimodality treatments. The proportion of AVMs treated microsurgically remained stable, while the proportion treated endovascularly increased dramatically, and the data demonstrate important patient-level distinctions amongst groups. Outcomes and complication profiles were significantly different between treatment modalities and were impacted by age and hemorrhage status.

Conclusions: Charges to the payer and society have increased dramatically without clear improvements in quality parameters. Analysis of treatment modalities has demonstrated differences and warrants further investigation to understand which patient population would benefit maximally from each. With only imprecise measurements of quality in healthcare delivery, it remains imperative to develop databases where parameters such as survival, functional outcomes, quality of life, and complication rates, can beassessed in order to examine the value of care delivered in a more meaningful way.

O-3
Stereotactic Radiosurgery for Arteriovenous Malformations in Children: A Single Institution Experience

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Aim: The aim of our study was to evaluate treatment *Results* and toxicity of stereotactic irradiation for arteriovenous malformations (AVMs) in children.

Material and Methods: A group of ten children (4 boys and 6 girls) irradiated between 2002 and 2010 at our institution was included into the study. Mean age at the time of treatment was 15.4 and ranged between 8 and 18 years. There were 2 Spetzler-Martin grade IV, 4 grade III and 4 grade II lesions. Mean AVM volume was 13.24 cm^3 and ranged between 0.56 and 36.8 cm^3. In 5 patients the planned dose of 16-20 Gy was delivered in single fraction, in 5 the total dose of 16-24 Gy was delivered in 2-3 fractions. One patient was reirradiated with a dose of 15 Gy in 7 years after the initial treatment.

Results: Median follow-up time was 38.5 months. The treatment resulted in total obliteration in 6 patients and partial in 3, in one no response to treatment was seen. Median time to obliteration was 17.9 months, Actuarial total obliteration rates were 34, 50 and 67% after one, two, and three years of follow-up, respectively. No patient bled after the treatment. In one patient new epileptic seizures developed after the treatment, in magnetic resonance imaging focal necrosis was revealed. In five patients asymptomatic imaging abnormalities were seen during follow-up.

Conclusions: Stereotactic radiosurgery is an effective method of treatment for pediatric AVMs , the patients however require meticulous follow-up because of relative high incidence of radiation-induced imaging abnormalities.

O-4
High-Volume Surgeons and Hospitals Provide Superior Care at Higher Value: a Volume-Outcome Analysis for Cerebral Arteriovenous Malformations

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Introduction: Treatment of cerebral arteriovenous malformations (AVMs) has grown in complexity with the development of multimodal approaches, and yet provision of care continues across a variety of settings. We assessed patient, surgeon, and hospital characteristics, including volume, as potential outcome predictors.

Methods: We examined data from 2000-2009 in the Nationwide Inpatient Sample, perform-

ing multivariate analyses of trends in microsurgical, radiosurgical, and endovascular treatment by hospital and surgeon.

Results: We identified 8912 patients with AVMs who were treated in US hospitals. We classified hospitals and surgeons by case volume and compared endpoints amongst quartiles. Compared to low-volume hospitals (2 or fewer cases/yr), high-volume hospitals (16 or more cases/yr) had shorter LOS (p=0.0002), higher total charges (p<0.0001), more frequent routine discharge to home (p<0.0001), and higher mortality (p<0.0001). Low-volume surgeons (1 or fewer cases/yr) had significantly different outcomes than high-volume surgeon (7 or more cases/yr), with the later having shorter LOS (p=0.03), more frequent routine discharge (p<0.0001), and lower mortality (p<0.007). The rates of surgery, angiography, and radiosurgery were significantly different in high- versus low-volume practices.

Conclusions: Treatment of AVMs performed at high-volume centers was associated with lower morbidity and for high-volume surgeons, lower mortality. These data suggest that the treatment of AVMs at large-volume institutions and by high-volume surgeons provides overall superior outcomes and superior value. We therefore advocate the creation of care paradigms that triage patients to high-volume institutions and surgeons that serve as centers of excellence for AVM management.

O-5
A Liquefying Haematoma Cavity Facilitates the Microsurgical Resection of AVMs or DAVFs

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Introduction and Objectives: The general recommendation for the microsurgical resection of AVM/DAVF when presenting with an intracranial haemorrhage is to delay it to an elective setting. We present our series of microsurgical resections during the 'subacute phase' (6 to 28 days post ictus) and discuss the utility of a liquefying haematoma cavity.

Methods: Review of prospectively collected database (2001-2012) (111 angiographically-proven AVMs and DAVFs). Inclusion criteria: patients presenting with AVM or DAVF following ICH, all involving the senior author, and had microsurgical resection of the vascular lesion in the 'subacute phase'. Outcome was assessed using the modified Rankin Score (mRS).

Results: 32 patients had the vascular malformations resected in the presence of a liquefying haematoma cavity. The ICH cavity provided a trajectory to a deep AVM/DAVF in 16 patients and deep dissection plane in the other 16. There were 29 AVM (Spetzler-Grade: I – 8; II – 13; III – 3; IV – 5) and 3 DAVF. 25 lesions were supratentorial and 7 infratentorial. The oblitaration rate was 100%. mRS after treatment: 0-3 (27/32); 4-5 (4/32); 6 (1/32).

Conclusions: The presence of an ICH cavity provides a 'window of opportunity', before its total resolution, to aid resection, providing a trajectory for a deep AVM/DAVF, and facilitating dissection on the deep surface of the nidus, without necessarily imposing added deficits.

O-6
"Intraoperative ICG Videoangiography as an Aid to The Surgical Treatment of Spinal Vascular Malformations."

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Objective: Intraoperative Indocyanine Green (ICG) Videoangiography has become an established aid to cerebrovascular surgery. We describe the application of this technique in our series of microsurgically treated vascular malformations of the spinal cord.

Method: ICG dye was administered as an intravenous injection and detected intraoperatively via 800nm filter on the surgical microscope.

Results: Twenty-three patients underwent microsurgery for vascular malformations of the spinal cord from September 2007 to March 2012. Eighteen were Type I spinal dural AVFs, 2 were Type II intramedullary lesions, 2 were Type IV perimedullary fistulae and 1 was an as yet unclassified spinal dural AV fistula.

Two of the Type I lesions were of a 'low-flow' subtype where obliteration of the fistula could most easily bedemonstrated with the ICG technique. In Type II and Type IV lesions the ICG

angiogram delineates the nidus or fistulae and allows intraoperative correlation with the pre-operative digital subtraction angiography (DSA).

No patient suffered a complication of dye administration. Intra-operative video is presented to illustrate the technique, in particular the case of an unclassified type of spinal vascular malformation where two distinct and distant points of fistulation are disconnected successfully. However its limitations are demonstrated in the case of a cervical Type II intramedullary lesion where a diffuse residual AVM was evident on post-operative imaging.

Conclusions: ICG Videoangiography is a time-efficient safe alternative to intraoperative spinal angiography. Although the technique has its limitations and cannot beregarded as a replacement for formal intraoperative DSA, it does provide invaluable intraprocedural information.

O-7
A Reliable Experimental Mouse Model for Chronic Cerebral Venous Hypertension

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Introduction: Induced chronic venous cerebral hypertension (CVH) is believed to play an important role in brain arteriovenous malformations pathogenesis and prognosis. Experimentally, an arteriovenous fistula surgically created between the common carotid artery (CCA) and the external jugular vein (EJV) in mice generates cerebral venous hypertension. However, pre-existing models did not show long-term patency of the fistula. We present a CCA-to-EJV end-to-side anastomotic fistula experimental mouse model that offers improved long-term patency of the fistula and sustained CVH.

Methods: After approval by our Committee on Animal Research, the C57BL/6J mice underwent CCA-to-EJV end-to-side fistula creation. Superior sagittal sinus pressures were prospectively measured at 2, 3 and 4 weeks after surgery. The fistula patency was confirmed by various methods during acute and chronic stages.

Results: All the fistulas were patent 4 weeks after surgery. All mice presented with typical right eye proptosis postoperatively. The postoperative 2-week sinus pressure was 8.8±1.2 mmHg, three-week was 4.7±1.4 mmHg, and four-week was 3.9±0.6 mmHg ($p<0.0001$). Postoperative 2-week sinus pressure was significantly higher than 3-week ($p<0.001$) and 4-week sinus pressures ($p<0.001$).

Conclusion: This reliable and durable CVH mouse model is useful for analyzing the pathogenesis of arteriovenous malformation, dural arteriovenous fistula, sinus thrombosis, and pathological disorders related to the jugular vein regurgitation. This novel mouse model showed that the sinus pressure remained elevated 4 weeks after the surgery. A two-week time interval offers the maximum and most homogeneous CVH effect after surgery. Adding knockout technology of transgenic mice, this technique should facilitate gene-related in vivo research.

O-8
Treatment of Cerebral Cavernous Malformations in Adults: Systematic Review

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Introduction: Cerebral cavernous malformation (CCM) treatment decisions are usually made by indirectly comparing the risks of CCM treatment against the known risks of the untreated natural history of CCM in the short-term (or extrapolations of these risks to patients' lifetimes). We tried to develop guidelines for CCM treatment using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) Working Group's approach.

Methods: We used electronic strategies to find original studies which included ≥20 adults with CCM who were treated, included a comparison group, reported clinical outcomes, and were published prior to 2011. We included studies classified as Level 1 (systematic reviews of randomised trials or n-of-1 trials) or Level 2 (randomised trials or observational studies with a dramatic effect [defined as a rate ratio of 10 or more, or a p value <0.01]) according to the Oxford Centre for Evidence-Based Medicine 2011 criteria.

Results: We did not identify any level 1 or 2 studies of adults with incidentally-discovered CCM. We identified five potentially eligible observational studies of adults with a CCM that had already bled, but we excluded them because none demonstrated a dramatic effect. We identified 11 potentially eligible observational studies of adults with CCM and epilepsy, but we excluded them because nine studies did not demonstrate dramatic effects whilst two studies showed dramatic effects (but they were at high risk of bias).

Conclusion: The absence of level 1 or 2 evidence for CCM treatment mandates large observational studies with a control group, ideally with randomised treatment allocation.

O-9
Staged Coil Occlusion for Giant Spinal Perimedullary Arteriovenous Fistula

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Purpose: To discuss the use of endovascular coil occlusion for giant type III spinal perimedullary arteriovenous fistula (GAVF).

Materials & Methods: Retrospective case review of three pediatric patients treated with coil occlusion.

Results: Case 1 was a 7-year-old female who presented with back pain and leg weakness. Initial MRI demonstrated a fistula in the thoracolumbar region with a large venous pouch. Coil occlusion of the venous pouch was performed on two separate occasions, 5 months apart. Follow-up MRI confirmed occlusion of the fistula. Her symptoms improved.

Case 2 was a 5-year-old male who presented with increasing spastic diplegia. Initial MRI demonstrated a mid-thoracic perimedullary fistula with an associated venous pouch. Coil occlusion was performed on two separate occasions, 2 months apart. Follow-up MRI confirmed occlusion of the fistula. His symptoms ultimately stabilized.

Case 3 was a 6-year-old male who presented with sudden onset headache. This was found to bedue to subarachnoid hemorrhage secondary to a cervical perimedullary fistula, which was associated with two large venous pouches supplied via the right thyrocervical artery and vertebral artery. There was a known history of hereditary hemorrhagic telengiectasia. Coil occlusion was performed via the thyrocervical artery. Supply via the vertebral artery was part-occluded with onyx as tortuous anatomy precluded coil deployment. Follow-up MRI demonstrated complete occlusion of the fistula. He made a full recovery.

Conclusion: Occlusion of giant type III spinal perimedullary fistulas via staged coil occlusion is a safe and effective treatment option.

O-10
The 30-Day Complication Rate Following Embolisation of Brain Arteriovenous Malformations or Associated Aneurysms: Prospective Population-Based Study

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Objectives: To determine the frequency of complications, and influences on them, following endovascular treatment of brain arteriovenous malformations (AVM) or associated aneurysms.

Methods: In a prospective, population-based observational study of newly-diagnosed AVMs in adults in Scotland between 1999-2003 and 2006-2010, we used multiple overlapping sources of ascertainment and follow-up to quantify the 30-day risk of death, focal neurological deficit, or radiolographically-confirmed cerebral infarction or haemorrhage attributable to endovascular treatment of a brain AVM or associated aneurysm.

Results: Of 459 adults with an AVM, 171 (37%) underwent intervention, of whom 90 (53%) were female, 102 (60%) presented with intracranial haemorrhage, and 68 (40%) had multiple procedures (262 embolisations and 26 coilings). Complications occurred within 30 days of 40/262 (15%; 95% confidence interval [CI] 11 to 20) AVM embolisations and 5/26 (19%; 95%CI 9 to 38) aneurysm coilings. The 30 day complication rate after AVM embolisation was not influenced by mode of AVM presentation (23/140 ruptured versus 17/122 unruptured; OR=1.2, 95%CI 0.6 to 2.3) or AVM Spetzler-Martin grade (20/143 grades I-II versus 20/119 grades III-V; OR=0.8, 95%CI 0.4 to 1.6). Over time, Onyx use increased (where the agent was specified, 36/105 procedures 2004-2011 versus 19/106 procedures 1999-2003; OR=2.4, 95%CI 1.3 to 4.5), and complications after embolisation seemed to become more frequent (chi-square for linear trend=3.6, p=0.06).

Conclusions: These Results from an unselected population-based sample are consistent with a recent meta-analysis. Further work will be undertaken to identify influences on these complication rates and their long-term functional impact.

O-11
Long-Term Follow-Up of Hemorrhagic Risk in Treated Brain Arteriovenous Malformations

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Patients with brain arteriovenous malformations (bAVMs) harbour a lifelong risk of intracranial hemorrhage. There are a number of predictors of hemorrhage in untreated bAVMs. Predictors of hemorrhagic risk in partially treated bAVMs remains poorly defined. We aim to review the clinical outcomes including hemorrhagic risk within our cohort of bAVMs treated with embolisation, both during the treatment period and in the long-term. From 1995 through to 2011, for all the patients who presented to our center for endovascular treatment of bAVM, we performed a consensus review of clinical presentation, imaging findings, types and frequency of treatment, response to treatment, and clinical outcomes within the treatment period and in the long-term. 216 patients (108 male, 108 female) presented for endovascular treatment of bAVM between 1995 and 2011. Average age at presentation is 35.1 years. 47% (n=101) of patients presented with hemorrhage. Multimodality treatment approach consisted of a combination of surgery, endovascular embolisation and radiosurgery. Periprocedural complications included none, transient or permanent neurological symptoms, asymptomatic or symptomatic hemorrhage, death or delayed complications. Endovascular treatment resulted in a complication rate of 36% (n=77), with 13% (n=29) risk of hemorrhage (includes asymptomatic and symptomatic). Long-term (>10 years) follow-up of a small proportion of completely treated bAVM patients demonstrate good clinical outcome with no risk of further hemorrhage.

Patients with bAVMs represent a heterogenous group. Treatment strategies are also heterogenous and are associated with hemorrhagic risk. Therefore, complete obliteration of the bAVM is the goal.

O-12
Temporal Lobe Arteriovenous Malformations: Surgical Strategy, Techniques, and Outcomes

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Introduction: The temporal lobe houses very complex and highly eloquent cortical anatomy. The variability in arterial supply and venous drainage makes AVM surgery particularly challenging in this location. We blended previous existing classifications into an intuitive and practical one to better understand surgical strategy. We analyzed our surgical experience with lateral, medial, basal, Sylvian and ventricular AVMs of the temporal lobe.

Methods: From a consecutive series of 500 patients, 88 had temporal AVMs. Characteristics, operative strategy and outcome were analyzed in these patients according to the 5 types of temporal AVM. Ilustrative cases were also selected.

Results: The majority of temporal AVMs were on the lateral surface of the lobe (58, 66%). MCA is the major supplier to lateral (55, 95%) and Sylvian types (5, 100%). PCA is more frequently involved with medial (69%) and ventricular (100%) AVMs. AChA supplied all ventricular AVMs and a majority of medial (54%) and Sylvian (60%). The approach was trans-sylvian to Sylvian and anterior medial AVMs; transcortical to lateral and ventricular types; and subtemporal for basal and posterior medial types. Complete resection was achieved in 82/88 patients. 83% were improved or unchanged after surgery. Four died perioperatively. Medial and ventricular AVMs had the highest immediate morbidity but the best long-term outcomes.

Conclusion: Understanding the complex anatomy of the temporal lobe is basic to a successful microsurgical treatment of AVMs in this location. An anatomic classification does not offer any meaningful prediction of surgical risk but offers crucial practical assistance for planning surgical strategy.